

9. RISK MANAGEMENT

The tunnel system, associated consolidation sewers, and diversion and control structures are subject to a number of technical risks and contractual challenges that are inherent to large underground civil projects. These risks will need to be addressed during the planning and design phases of the project, and updated and managed through construction of all structures and facilities.

Effective risk management and risk reduction, through continuous assessment, mitigation and contingency planning, are an essential and prudent management strategy. A systematic risk identification, evaluation and management strategy will lead to early identification of risks and allow deployment of appropriate mitigation of possible onerous situations. A risk registry can be used to establish the basis for management of technical, contractual and socio-economic risks in the planning phase, subsequent preliminary engineering and design phases, and ultimately in the contract documents and construction management process. A risk registry is a compilation of identified risks from sources that can affect or have an impact on a specific aspect of the project. In general, each identified risk factor is analyzed to determine the likelihood of occurrence and the potential impact to the project if it did occur. A risk with a low likelihood of occurrence and a very small impact to the project if it did occur might be dropped from the risk registry. If the risk with a low likelihood of occurrence would have a large impact to the project, it would remain on the registry list so that an appropriate mitigation strategy could be developed.

The risk management strategy provides the Owner a structured decision-making process on how to select the most cost effective risk mitigation or response option for each risk or risk category. Often, this process is influenced by the risk tolerance of the Owner and the contracting environment. The best strategy is early mitigation of risks with zero or minimal cost to avoid the risk. For example, in this early planning phase of the Fall Creek/White River Tunnel project, this could mean:

- ◆ Modification of shaft locations and tunnel alignment away from identified and unmanageable risks

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- ◆ Control cost escalation risk by scope management and limiting the number of added features from original concepts and budgets
- ◆ Identification and address of potential socio-economic risks through an effective community outreach program
- ◆ Identification of potential third party involvement and impacts

It also is important to assign a probability or likelihood of occurrence and its consequences to each risk or risk factor that will create an impact on the project cost and schedule. The risk probability or risk quantification factor is used to calculate the Owner's exposure to risk in a dollar value that is weighted against the cost of the mitigation option(s). This allows the Owner to make cost effective decisions as to how to mitigate risks and associated potential damages. This component of the risk management strategy is often difficult to assess because of the number of variables involved.

The Owner's position on risks will depend on the following:

- ◆ Type and nature of risks involved and options available for mitigation
- ◆ Ability to avoid risks through design and construction method specifications
- ◆ Ability to reduce or allocate the risks
- ◆ Ability to absorb risks through a careful contingency plan that also includes the appropriate use of insurance

Industry-wide tunneling risk management guides are defined primarily by the American Society of Civil Engineer's (ASCE) and the American Underground Construction Association's (AUA) underground construction risk assessment committees, and are generally applicable to Contract Documents for managing specific geotechnical risks. The following presents technical, contractual and socio-economic components of various types of risks and associated potential mitigation options for tunneling projects.

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9.1 Technical Risk Management

The technical risk management aspects are unique to the project and pinpoint areas of concerns that are related to the construction of a large diameter tunnel and associated surface structures in congested urban areas. Multiple stakeholder technical concerns and issues also are included in the technical risk management category. These issues and other risk factors may be the result of actions or in-actions that occur in the preliminary engineering and design phases. Subsequently, these concerns are mitigated by choosing appropriate tunnel and shaft construction means and methods. Table 9.1 summarizes the potential technical risks that are typical for a large tunnel project and the available mitigation options.

Table 9.1 Summary of Potential Technical Risks and Mitigation Options	
Potential Technical Risk	Mitigation Option
Significant increase in costs	<ul style="list-style-type: none">◆ Formal Design Review Board of renowned geotechnical, tunneling, hydraulics and tunnel operational experts involved during design◆ “Bottom-up” construction cost estimating early in the process similar to methods used by Contractors that applies crew sizes, equipment rates and level of effort in crew hours for each element of the project
Property damage and economic damage to the community and other stakeholders	<ul style="list-style-type: none">◆ Geotechnical exploration program with a phased boring program◆ Utility assessment prior to construction◆ Install instrumentation on and near sensitive structures and utilities during construction to monitor for settlement and ground movement◆ Formal risk analysis to identify the likelihood of an event occurring, the impacts, and seriousness◆ Cost effective decisions based on the formal risk analysis◆ Community and business outreach programs◆ Implementation of a comprehensive insurance program◆ Specified traffic mitigation plan and construction phasing to lessen the impact

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Table 9.1 Summary of Potential Technical Risks and Mitigation Options	
Potential Technical Risk	Mitigation Option
Failures during construction and potential loss of life	<ul style="list-style-type: none"> ◆ Establishing a proactive approach to groundwater monitoring and control ◆ Thorough analysis of results from geotechnical findings and review by external independent consultants ◆ Sound and economical design of temporary support systems requirements ◆ Clear identification of potential geotechnical issues and their impacts ◆ Comprehensive review of Contractor's "means and methods" ◆ Close monitoring of Contractor's operations ◆ Flexibility and close working relationship with Contractor ◆ Implementation of proven safety programs focused on prevention with incentives
Delays in project completion	<ul style="list-style-type: none"> ◆ Ongoing critical path management analysis with "float" clearly identified ◆ Verification of procedures to ensure the project schedule and its potential delays are managed ◆ Early involvement and input from construction industry
Not attaining design, operational, maintainability and quality standards	<ul style="list-style-type: none"> ◆ Independent QA/QC team ◆ Inter-disciplinary review and constructability reviews ◆ Close coordination with the City of Indianapolis' (City) Operations and Maintenance staff and adherence to their standards
Construction claims and disputes related to differing site conditions, encountering obstructions, ground water infiltration, hazardous materials	<ul style="list-style-type: none"> ◆ Prepare a Geotechnical Baseline Report (GBR) to establish the baseline clearly defining the City's level of construction risks ◆ Develop special provisions in the contract to include a GBR and Disputes Review Board, if used ◆ Appropriate usage of insurance and risk taking

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9.2 Contractual Risk Management

There are numerous contractual and risk allocation/management issues that need to be evaluated regardless of the chosen delivery method. These issues take the form of draft construction contract provisions for consideration by the City's management staff to discuss specific risk allocation options on these management issues. Table 9.2 summarizes the potential contractual risks and the available mitigation options.

<p>Table 9.2 Summary of Potential Contractual Risks and Mitigation Options</p>	
Potential Contractual Risk	Mitigation Options
Management of Geotechnical Reports	<ul style="list-style-type: none"> ◆ Type of information furnished to the Contractor ◆ Include disclaimer in connection with the furnishing of the information ◆ Order of precedence among data reports, interpretive reports and other geotechnical reports ◆ Define the risk allocation level within the GBR and define the boundaries of risk transfer between the Owner and Contractor
Management of Design Approach	<ul style="list-style-type: none"> ◆ Apply performance specifications regarding construction "means and methods" within the Contract Documents ◆ Consider the Design-Build delivery method as an option ◆ Permit use of innovative contracting practices and techniques ◆ Conduct "lessons learned" seminars periodically throughout the duration of the project with all project participants
Management of Construction	<ul style="list-style-type: none"> ◆ Potential use of Value Engineering or design substitutions ◆ Potential use of a Dispute Review Board process within the Contract Documents ◆ Limit the Dispute Review Board's responsibilities to technical issues and not contractual issues ◆ Scope and availability of professional liability insurance, general liability insurance, builder's risk insurance and surety protection ◆ Identify and evaluate risk allocation/transfer mechanisms by either contractual or risk transfer (insurance)

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9.3 Socio-Economic Risk Management

The socio-economic risk category generally includes impacts on the communities, businesses, and profit or non-profit interest groups. These entities may have their own expectations of the project, development plans including areas beyond the tunnel footprint, and political interests. These risks are difficult to identify until project plans are completed and thoroughly discussed with the public and all other interest groups. An effective community outreach program, as discussed in Section 8 – Project Considerations, will help identify and manage most risks in this category.

9.4 Preliminary Risk Registry for Fall Creek/White River Tunnel Project

The risk management objectives for the Fall Creek/White River Tunnel project can be summarized as follows:

- ◆ Validate alignment selection at planning stage with appropriate subsurface exploration program and analysis of associated risks
- ◆ Develop and implement appropriate cost and schedule control
- ◆ Design project facilities in a manner that will reduce or eliminate the risks
- ◆ Select an alignment that minimizes construction risks and impacts on groundwater supplies
- ◆ Specify methods of tunneling and shaft construction that will minimize identified risks
- ◆ Specify monitoring and controls to be implemented during construction that will warn against the risks
- ◆ Prepare contract documents, including a Geotechnical Baseline Report, that have equitable payment provisions
- ◆ Properly allocate risks in the Contract Documents

A preliminary or starter risk registry for the Fall Creek/White River Tunnel project could include the following (not in any specific order) and can be updated and addressed as data becomes available:

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- ◆ Groundwater management
 - Exfiltration or potential groundwater quality impacts on nearby public water supply wells
 - Excessive groundwater infiltration during construction and flooding of tunnel
 - Depletion of groundwater supplies
 - Excessive groundwater infiltration during operation, thereby reducing available capacity and increasing treatment costs
 - Impact of pre-excavation grouting on existing wells
- ◆ Geotechnical conditions
 - Tunnel roof instability hazards
 - Rock hardness and strength
 - Lower rock quality that requires additional support
 - Significant geologic discontinuities – faults, shear zones, and solution features
 - Methane and hydrogen sulfide gas release into excavations
 - Blasting induced vibration and air-blast impacts
 - Settlement in soils
 - Occurrence of boulders in soils
 - Boreholes or wells mistakenly left open
 - Ground loss during excavation of soils caused by soil beyond the tunnel envelope or shaft footprint entering the excavation
- ◆ Other natural and man-made obstructions or features
 - Encountering unidentified utilities
- ◆ Construction under waterways and rivers
- ◆ Malfunction of equipment due to wear, corrosion, mechanical failure, human error, etc.
- ◆ Worker safety issues from naturally occurring gases
- ◆ Industrial accidents to workers due to human error or other causes
- ◆ Encountering contaminated soil and/or groundwater
- ◆ Tunnel water discharge quality during construction

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- ◆ Cost escalation
- ◆ Socio-economic risks and third party issues
- ◆ Unanticipated events

This list, though certainly not all inclusive, covers the most common types of risk in tunneling projects. The Owner/Engineer's challenge is to anticipate the potential risks, possible effects and probability of occurrence to develop and deploy effective risk mitigation options. In a traditional design-bid-build procurement environment, highly qualified and experienced engineers, independent design review board engagement and well-prepared Contract Documents, including a Geotechnical Baseline Report, will help greatly to reduce, properly allocate or mitigate the risks. However, all risks cannot be removed completely from an underground construction project. Therefore, it is also important to require and implement rigorous safety programs as well as consider insurance to complement the risk management strategy.